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(54) 【発明の名称】 被覆超硬エンドミル

(57) 【要約】

【目的】 本発明は、高硬度材の乾式高速切削で長い工具寿命を達成するため、切粉が赤熱し工具に凝着する、高温のためエンドミル刃先部が微少に塑性変形を防ぎ工具寿命を延す超硬エンドミルを提供する。

【構成】 A l と T i を主成分とし、C、N、O、Bの一種以上から構成される皮膜とC r を主成分とし、C、N、O、Bの一種以上から構成される皮膜を少なくとも2層以上被覆した超硬エンドミルにおいて、その母材である超硬合金のC o の含有量が5重量%から12重量%、保磁力が15 k A / m 以上であり、C o の ( 1 1 1 ) 面から算出される格子定数が3.565 Å 以上で構成する。

## 【特許請求の範囲】

【請求項1】AlとTiを主成分とし、C、N、O、Bの一種以上から構成される皮膜とCrを主成分とし、C、N、O、Bの一種以上から構成される皮膜を少なくとも2層以上被覆した超硬エンドミルにおいて、その母材である超硬合金のCoの含有量が5重量%から12重量%、保磁力が15kA/m以上であり、Coの(111)面から算出される格子定数が3.565Å以上であることを特徴とする被覆超硬エンドミル。

【請求項2】請求項1記載の被覆超硬エンドミルにおいて、前記AlとTiを主成分とし、C、N、O、Bの一種以上から構成される皮膜のTiの一部をZr、Cr、Si、Nb、W、Yの一種または二種以上で置き換えたことを特徴とする被覆超硬エンドミル。

【請求項3】請求項1及び2記載の被覆超硬エンドミルにおいて、前記Crを主成分とし、C、N、O、Bの一種以上から構成される皮膜のCrの一部をV、Si、Tiの一種または二種以上で置き換えたことを特徴とする被覆超硬エンドミル。

## 【発明の詳細な説明】

## 【0001】

【発明の属する技術分野】本発明は乾式高速切削において、耐溶着性及び耐塑性変形性に優れた被覆超硬エンドミルに関する。

## 【0002】

【従来の技術】近年切削加工は高速化の傾向にあり、切削温度も極めて高くなっている。従って、従来一般的であったTiN、TiCN等の被覆では、耐酸化性が十分でなく、それを解決するために、耐酸化性の優れたTiAlN系皮膜が用いられるようになってきた。TiAlN系Ti系皮膜より耐酸化性は優れたものである。さらに最近では、特開平8-132310号公報、特開平11-156992号公報のように、潤滑性膜を加えた工具が提案されている。

## 【0003】

【発明が解決しようとする課題】本発明者は高硬度材の高速切削を詳細に実施した結果、高硬度材の乾式高速切削においては、長い工具寿命を達成するために、新に二つの現象に対する対策が必要であることを確認した。一つは切粉が赤熱し、工具に凝着することが確認されこれに対する解決策。もう一つは、高温のため、エンドミル刃先部が微量に塑性変形し、これに伴い摩耗が進行することが確認されこれに対する解決策である。この二つの現象が工具寿命を低下せしめるとともに、加工面の仕上げ面粗さを劣化させる要因となっている。

## 【0004】

【課題を解決するための手段】上記課題を解決するため、AlとTiを主成分とし、C、N、O、Bの一種以上から構成される皮膜とCrを主成分とし、C、N、O、Bの一種以上から構成される皮膜を少なくとも2層

以上被覆した超硬エンドミルにおいて、その母材である超硬合金のCoの含有量が5重量%から12重量%、保磁力が15kA/m以上であり、Coの(111)面から算出される格子定数が3.565Å以上であることを特徴とするものである。すなわち、本発明では、皮膜の改良においては、一般にTiAlN系は鋼との摩擦係数が0.8前後と高いため、皮膜に潤滑性を持たせるために鋼との摩擦係数の低いCrN系皮膜との複合多層化により、0.4程度まで低減することを確認した。CrN系は耐凝着性には優れたものの軟らかく耐摩耗性には劣るため、耐摩耗性に優れたTiAlN系皮膜との多層構造とするほうがより好ましいがTiAlN系との2層構造でも十分である。また、皮膜のみの耐凝着性の改善では、切削寿命が2割程度しか向上するにすぎなかった。さらに詳細に検討を重ねた結果凝着は、母材そのもの発生している事実を突き止めるに至った。つまり、切削初期において、母材は皮膜で保護されているため、皮膜の耐凝着性の改善により効果が確認されるわけであるが、切削中期以降は母材が露呈し、皮膜のみの効果ではその凝着防止に対する寄与が少ない訳である。

## 【0005】

【作用】母材で発生する凝着は、超硬合金中のCoと鋼の間で発生する。鋼と超硬合金を高温で拡散接着しその接合強度を測定した結果、接合強度は超硬合金のCoのミーンフリーパス、つまりWC粒子の平均粒子間距離に強く依存することが確認された。WC粒子間距離が大きい場合、つまりWC粒子間のCoの厚さが厚い場合接合強度は著しく高くなる傾向にあった。従って母材での凝着を抑制するためには、WC粒子間のCoの厚さをある数値以下にすると凝着が改善できることを見出した。WC粒子間のCoの厚さは超硬合金の保磁力と相関があり、WC粒子間のCoの厚さが薄くなるにともない保磁力は増加する。従って、超硬合金の保磁力をある数値以上にすることがあるわけである。接合強度はある保磁力以上で著しく減少し、結果母材での凝着を著しく抑制するものである。

【0006】次に耐塑性変形性はCoの格子定数を規定することにより解決される。塑性変形は超硬合金の中の金属相であるCoですべりが発生することにより生ずる。塑性変形が発生すると切れ味が悪くなり凝着が加速されることも実験により明らかとなった。Coに固溶するW、Ti、Taと言った重金属成分を増やしCo金属相を固溶強化することにより、耐塑性変形性は改善される。これら成分の固溶量の増加にともないCoの格子定数は増加する。固溶量を増加させる手法としては、合金のカーボン量を低い側で制御するか、もしくは焼結後急冷却するかにより達成される。

【0007】上述のように、TiAlN系皮膜とCrN系皮膜の複合化、及び母材のWC粒子間距離の調整、並びにCoを固溶強化し耐塑性変形性を抑制するという3

点の同時改良により、皮膜のみの改良では2割程度の寿命向上にすぎなかったが、寿命は6割以上改善されるとともに、仕上げ面粗さも極めて優れる結果となった。さらに耐酸化性を高める目的でTiAlNを主成分とする層のTiの一部をCr、Zr、Nb、Si等の成分に置換することが有効で、さらに寿命の向上が可能となる。これら成分はTiAlN結晶の主に粒界の格子欠陥に偏析し、粒界を緻密化し酸素の拡散を抑制するものである。

【0008】次に、CrN系皮膜にVを添加することにより、切削中皮膜表面に潤滑性の優れるVの酸化物が形成されCrN系の潤滑性を飛躍的に高めることが可能となった。一方CrN系皮膜は潤滑性を有するものの、硬度が低く耐摩耗性の観点からはあまり好ましいものではない。この欠点を克服するためには、Si、もしくはTiの添加が有効である。Si、Ti添加によりCrN系皮膜の硬度は向上し、結果潤滑性を保ちながら、耐摩耗性を付与でき、さらに切削寿命を向上せしめることが可能である。さらに、潤滑性改善のVと硬度向上のTi、Siの一種を複合添加することがより好ましい。

【0009】次に数値限定した理由について説明する。Co含有量は5重量%未満であると超硬合金の靱性が低下し、チップングが発生し易くなり、13重量%を超えると鋼との凝着が顕著となるため5重量%以上13重量%以下とした。Coの格子定数は3.565Å未満であると、Coの固溶強化が十分でなく切削中に塑性変形の発生、それに伴う凝着の発生が生じ好ましくないため、

3.565Å以上とした。保磁力は15kA/m未満であると凝着が発生し易くなるため15kA/m以上とした。さらに好ましい範囲は5~8重量%のCo含有超硬に対しては15kA/m以上、8~11重量%のCo含有超硬に対しては20kA/m以上、11~13重量%のCo含有超硬に対しては25kA/m以上である。

【0010】

【実施例】以下実施例に従い本発明を説明する。アーカイオンブレーティング法により、表1に示す本発明例及び比較例を作成した。皮膜の組成は蒸発源であるカソードの金属ターゲットの組成を調整することにより調整した。炉の片側にTiAl系ターゲット、反対側にCr系ターゲットを設置し交互に放電せしめることにより多層化を行った。被覆条件は基体に印可するバイアス電圧は150V、反応圧力は1Paで一定とし、皮膜厚さは全ての例において総厚3000nmとした。超硬合金は市販の平均粒径0.5μ、0.8μ、1.5μのCrをドーピングしたWC粉末、及び同1μのCo粉末をアルコール中、アトライターで10時間混合した後、乾燥させ、丸棒をラバープレスし、1350℃~1400℃1時間真空焼結することにより作成した。WC粒径及び焼結温度により合金の保磁力を調整した。また本発明例の合金においては、焼結後窒素ガスを封入することにより、急冷却を行い、目的とするCoの格子定数を得た。比較例においては炉冷した。

【0011】

【表1】

		母材組成(wt%)			WC粒径 μm	超硬合金特性		皮膜		層数
		WC	Co	Cr		保磁力 kA/m	格子定数(Å)	TiAlN系	CrN系	
本發明例	1	bal	5.5	0.5	0.8	35.5	3.570	50A150Ti-N	95Cr5V-N	6
	2	"	5.5	"	1.5	25.9	3.569	"	"	6
	3	"	8.0	"	0.6	34.0	3.570	"	"	6
	4	"	8.0	"	0.8	30.5	3.566	"	"	6
	5	"	8.0	"	0.8	32.2	3.574	"	"	6
	6	"	8.0	"	1.5	19.8	3.568	"	"	6
	7	"	12.5	"	0.6	28.5	3.569	"	"	6
	8	"	12.5	"	0.8	22.1	3.569	"	"	6
	9	"	12.5	"	0.8	24.0	3.574	"	"	6
	10	"	8.0	"	0.8	30.5	3.568	50A150Ti-95N50	95Cr5V-N	6
	11	"	"	"	"	"	"	50A150Ti-90N100	"	6
	12	"	"	"	"	"	"	50A150Ti-95N5B	"	6
	13	"	"	"	"	"	"	50A150Ti-90N10B	"	6
	14	"	"	"	"	"	"	50A150Ti-95N5C	"	6
	15	"	"	"	"	"	"	50A150Ti-N	95Cr5V-95N50	6
	16	"	"	"	"	"	"	"	95Cr5V-95N5B	6
	17	"	"	"	"	"	"	"	95Cr5V-95N5C	6
	18	"	"	"	"	"	"	"	95Cr5Si-N	6
	19	"	"	"	"	"	"	"	95Cr5Ti-N	6
	20	"	"	"	"	"	"	"	90Cr5V5Si-N	6
	21	"	"	"	"	"	"	50A145Ti5Zr-N	CrN	6
	22	"	"	"	"	"	"	50A145Ti5Cr-N	"	6
	23	"	"	"	"	"	"	50A145Ti5Si-N	"	6
	24	"	"	"	"	"	"	50A145Ti5Nb-N	"	6
	25	"	"	"	"	"	"	50A145Ti5W-N	"	6
	26	"	"	"	"	"	"	50A145Ti5Y-N	"	6
	27	"	"	"	"	"	"	50A140Ti5Nb5Y-N	"	6
	28	"	"	"	"	"	"	65A135Ti-N	95Cr5Si-N	2
	29	"	"	"	"	"	"	"	"	20
	30	"	"	"	"	"	"	"	"	100
	31	"	"	"	"	"	"	"	"	600
比較例	32	Bal	4.5	0.5	0.8	37.5	3.565	50A150Ti-N	95Cr5V-N	6
	33	"	14.0	0.5	0.8	19.6	3.569	"	"	6
	34	"	14.0	0.5	1.5	13.5	3.569	"	"	6
	35	"	8.0	0.5	0.8	28.7	3.559	"	"	6
	36	"	"	"	"	25.6	3.556	"	"	6
	37	"	"	"	"	20.5	3.555	"	"	6
	38	"	"	"	"	"	"	TiN	50A150Ti-N	6
	39	"	"	"	"	"	"	Ti-50N50C	50A150Ti-N	6
	40	"	"	"	"	"	"	50A150Ti-N	-	1
	41	"	"	"	"	"	"	50A145Ti5Cr-N	-	1
	42	"	"	"	"	"	"	50A150Ti-95N50	-	1
	43	"	"	"	"	"	"	50A150Ti-N	50Ti50Zr-N	6
	44	"	"	"	"	"	"	50A150Ti-N	200nm MoS <sub>2</sub>	2
	45	"	"	"	"	"	"	50A150Ti-N	200nm DLC	2
	46	"	"	"	"	"	"	50A150Ti-N	50Ti50Si-N	2

【0012】表1に示した本発明例及び比較例において、以下の切削条件で切削評価を実施した。その結果を表2に示す。本条件においてはエンドミルが赤変し折損するまで切削を実施し、折損までの切削長を寿命とした。また面粗さは切削1m後に測定し比較した。

切削条件1

被削材：SKD11 (HRC62)

工具：φ8mm、6枚刃エンドミル

切削速度：200m/min

切りこみ：8mm×0.4mm

送り：0.03mm/刃

乾式切削

【0013】

【表2】

		切削条件1		切削条件2	
		寿命	仕上面	摩耗 $\mu\text{m}$	仕上面
本 発 明 例	1	35	0.8	145	2.2
	2	26	0.6	165	2.1
	3	34	0.7	154	2.5
	4	33	0.7	150	2.2
	5	43	0.7	132	2.1
	6	30	0.8	164	2.0
	7	25	1.2	155	2.1
	8	23	1.3	162	2.4
	9	28	0.9	142	1.8
	10	38	0.6	123	2.1
	11	42	0.5	126	2.0
	12	44	0.5	128	2.4
	13	40	0.6	119	2.0
	14	36	0.7	143	2.1
	15	44	0.5	148	1.8
	16	47	0.5	152	1.7
	17	45	0.6	147	1.9
	18	53	0.5	116	1.5
	19	45	0.7	163	2.0
	20	55	0.6	110	1.5
	21	37	1.4	135	2.4
	22	38	1.2	133	2.2
	23	36	1.1	132	2.1
	24	42	0.9	140	1.9
	25	36	0.9	139	1.8
	26	36	1.0	144	2.0
	27	39	0.8	141	2.1
	28	49	0.8	159	2.5
	29	55	0.7	141	2.1
	30	56	0.6	132	1.9
	31	60	0.6	128	1.8
比 較 例	32	3	3.5	632	11.2
	33	21	0.8	342	3.5
	34	5	0.7	380	3.2
	35	22	0.7	285	3.3
	36	17	0.7	299	3.3
	37	15	0.7	342	3.9
	38	18	2.8	238	6.2
	39	20	3.0	220	6.1
	40	25	3.1	228	5.9
	41	24	3.2	278	5.3
	42	22	2.9	321	6.2
	43	20	2.8	378	6.6
	44	20	0.6	225	6.2
	45	18	2.2	221	6.3
	46	17	2.3	245	6.9

【0014】表2から明らかなように、本発明例1～9では、WC粒径とCo量を調整し、の格子常数とした例で、WC粒径が小さいほど、寿命が延びる傾向にある。更に、本発明例10～14では、試料番号4の超硬合金を用いて、膜質を酸素を含有するTiAlN-CrVN膜を用いて、20%前後の寿命延長が計れた。次にCrVNに酸素及び／又は他元素を添加した本発明例15～20では、更なる効果が確認された。また、同様に、本発明例21～27のTiAlN膜中に他元素を添加した場合にも、添加した元素によりその作用が特徴付けられた。最後に、本発明例28～31は、2層から600層まで層を重ねた場合であり、全膜厚は同じであり、層を重ねることに耐摩耗性は改善された。また、本発明例の面粗さは1.4ミクロン以下で、また、イレギュラー

なカッターマークもなく良好な結果が得られた。本発明例においては、凝着、塑性変形の発生が少なく長寿命である。特に塑性変形が発生し易い高硬度材高速条件下ではさらに比較例との差が顕著であることも明らかである。

【0015】比較例では、Co量が少ない比較例32、Co量が多い比較例33、34では、初期欠損、摩耗により寿命となった。格子常数を3.565未満とした比較例35～37では、切削初期は良いが、母材が露出すると急速に摩耗が進行し、寿命となった。更に、比較例37の母材を用いて、様々な膜質、膜の構成を試験した比較例38～46では、若干の効果はあるものの、膜が作用する切削初期は良いが、母材が露出すると急速に摩耗が進行し、寿命となった。

【0016】更に、表1に示した本発明例及び比較例において、ボールエンドミルを製作し、以下の条件において、50m切削あとの外周刃の最大摩耗を測定し比較した。また、仕上げ面粗さは50m切削後、切削方向において測定し比較した。その結果も表2に併記する。

切削条件2

被削材：S50C（HRC35）

工具：φ10mm、ボールエンドミル

切削速度：314m/min

切りこみ：0.3mm、ピック0.3mm

送り：0.5mm/刃

乾式切削

【0017】表2より、本発明例は、ボールエンドミルに特有な回転中心付近の切削のみを継続して行う条件であり、回転中心付近の損傷、特に凝着の影響を観察すると、50m切削後でも、摩耗が165ミクロン以下と小さく、また凝着等も少なく、面粗さも2.4ミクロン以

下が安定して得られている。比較例においては、摩耗量も大きい、それ以上に面粗さが大きな数値となっている。これは、母材が露出してくる50m切削後では、母材に切屑の一部が凝着をおこし、切削面がむしれるような状態となっている為である。また、本発明により高硬度材の高速切削において、被削材の凝着の防止、並びに刃先に発生する塑性変形の抑制により、極めて長い間の切削が可能となった。また、炭素鋼の切削においても同様の結果となった。これは限定された超硬合金と限定された皮膜の相乗効果によることは言うまでもないことである。また本発明例は凝着が発生し易いその他の被削材においても同様な効果が確認された。

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【0018】

【発明の効果】本発明を適用することにより、乾式高速切削で長い工具寿命が得られた。特に、凝着と耐塑性変形性を必須とする高硬度材において優れるとともに、凝着が発生し易いその他の被削材においても同様である。

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(71)Applicant : HITACHI TOOL ENGINEERING LTD

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(54) COATED CEMENTED CARBIDE END MILL

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a cemented carbide end mill capable of preventing fine plastic deformation at an end mill tip part caused by high temperature due to sticking of red-heated chips on a tool to increase the tool service life for achieving a long tool service life in dry and fast cutting to high hardness material.

SOLUTION: In this cemented carbide end mill coated with at least two layers of coating mainly comprising Al and Ti, and composed of at least one sort of C, N, O, B, and coating mainly comprising Cr, and composed of at least one sort of C, N, O, B, Co content in cemented carbide alloy as base material is 5 wt.% to 12 wt.%, a coercive force is more than 15 kA/m, and a lattice constant determined based on face (111) of Co is more than 3.565 Å.

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**CLAIMS**

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[Claim(s)]

[Claim 1] In the superhard end mill which covered at least the coat which uses aluminum and Ti as a principal component, uses as a principal component the coat and Cr which consist of more than kinds of C, N, O, and B, and consists of more than kinds of C, N, O, and B more than two-layer The covering superhard end mill characterized by for the content of Co of the cemented carbide which is the base material being 12 % of the weight from 5 % of the weight, for coercive force being 15 or more kA/m, and the lattice constant computed from the field (111) of Co being 3.565A or more.

[Claim 2] The covering superhard end mill which uses said aluminum and Ti as a principal component, and is characterized by replacing a part of Ti of the coat which consists of more than kinds of C, N, O, and B by kind of Zr, Cr, Si, Nb, W, and Y, or two sorts or more in a covering superhard end mill according to claim 1.

[Claim 3] The covering superhard end mill which uses said Cr as a principal component and is characterized by replacing a part of Cr of the coat which consists of more than kinds of C, N, O, and B by kind of V, Si, and Ti, or two sorts or more in claim 1 and a covering superhard end mill given in two.

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## DETAILED DESCRIPTION

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### [Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the covering superhard end mill excellent in joining-proof nature and plastic deformation-proof nature in dry type high speed cutting.

[0002]

[Description of the Prior Art] Cutting is in the inclination of improvement in the speed, and is very high [ cutting temperature ] in recent years. Therefore, in covering of conventionally common TiN, TiCN, etc., oxidation resistance is not enough, and in order to solve it, an oxidation-resistant excellent TiAlN system coat has come to be used. Oxidation resistance is superior to a TiAlN system Ti system coat. Furthermore, recently, the tool which added the lubricative film is proposed like JP,8-132310,A and JP,11-156992,A.

[0003]

[Problem(s) to be Solved by the Invention] this invention person checked that a cure in two phenomena was newly required, in order to attain a long tool life in the dry type high speed cutting of high degree-of-hardness material, as a result of carrying out high speed cutting of high degree-of-hardness material in a detail. One is a solution [ as opposed to / a chip becomes red-hot, and agglutinating a tool is checked, and / this ]. For an elevated temperature, the end mill edge-of-a-blade section deforms plastically very small, it is checked that wear advances in connection with this, and another is a solution over this. These two phenomena are the factor which degrades the machined surface granularity of a processing side, while making a tool life fall.

[0004]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, use aluminum and Ti as a principal component and the coat and Cr which consist of more than kinds of C, N, O, and B are used as a principal component. In the superhard end mill which covered at least the coat which consists of more than kinds of C, N, O, and B more than two-layer The content of Co of the cemented carbide which is the base material is 12 % of the weight from 5 % of the weight, coercive force is 15 or more kA/m, and it is characterized by the lattice constant computed from the field (111) of Co being 3.565Å or more. That is, in this invention, in amelioration of a coat, generally, since a TiAlN system had coefficient of friction as high as 0.8 order with steel, in order to give lubricity to a coat, it checked decreasing to about 0.4 by compound multilayering with a CrN system coat with low coefficient of friction with steel. Although excelled in adhesion-proof nature, since it is softly inferior to abrasion resistance, although it is more more desirable for a CrN system to consider as multilayer structure with the TiAlN system coat which is excellent in abrasion resistance, two-layer structure with a TiAlN system is also enough as it. Moreover, in the improvement of the adhesion-proof student of only a coat, the cutting life improved only about twenty percent. As a result of repeating examination in a detail furthermore, adhesion came to trace the fact which is carrying out the base material [ itself ] generating. That is, in the early stages of cutting, although effectiveness is checked by the improvement of the adhesion-proof nature of a coat since the base material is protected by the coat, it is exposed of a base material after the cutting middle, and the contribution to the adhesion prevention is few translations by the effectiveness of only a coat.

[0005]

[Function] The adhesion generated with a base material is generated between Co in cemented carbide, and steel. As a result of carrying out diffusion adhesion of steel and the cemented carbide at an elevated temperature and measuring the bonding strength, depending for bonding strength in the distance between average particles of the MIN free pass of Co of cemented carbide, i.e., WC particle, strongly was checked. When the distance between WC particles was large (i.e., when the thickness of Co between WC particles is thick), bonding strength suited the inclination which becomes remarkably high. Therefore, in order to control the adhesion in a base material, when thickness of Co between WC

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particles was made below into a certain numeric value, it found out that adhesion was improvable. The coercive force of cemented carbide and correlation have the thickness of Co between WC particles, the thickness of Co between WC particles follows on becoming thin, and coercive force increases. Therefore, it is necessary to carry out coercive force of cemented carbide beyond a certain numeric value. Bonding strength decreases remarkably above a certain coercive force, and controls the adhesion in a result base material remarkably.

[0006] Next, plastic deformation-proof nature is solved by specifying the lattice constant of Co. Plastic deformation is produced when a skid occurs in Co which is a metal phase in cemented carbide. When plastic deformation occurred, it also became clear by experiment that sharpness worsens and adhesion is accelerated. Plastic deformation-proof nature improves by increasing the heavy-metal component called W, Ti, and Ta which dissolve to Co, and carrying out solid solution strengthening of the Co metal phase. The lattice constant of Co increases with the increment in the amount of dissolution of these components. As technique to which the amount of dissolution is made to increase, it is attained by whether the amount of carbon of an alloy is controlled by the low side, or after [ sintering ] sudden cooling is carried out.

[0007] As mentioned above, although it was only improvement in a life of about twenty percent in amelioration of only a coat, the life resulted in it being extremely excellent also in machined surface granularity by them while compound-izing of a TiAlN system coat and a CrN system coat and adjustment of the distance between WC particles of a base material, and coincidence amelioration of three points of carrying out solid solution strengthening of the Co to a list, and controlling plastic deformation-proof nature had improved 60 percent or more. It is effective to permute a part of Ti of the layer which uses TiAlN as a principal component in order to raise oxidation resistance furthermore by components, such as Cr, Zr, Nb, and Si, and improvement in a life of it is still attained. These components are segregated to the Lord of a TiAlN crystal at the lattice defect of a grain boundary, carry out eburnation of the grain boundary, and control diffusion of oxygen.

[0008] Next, it became possible by adding V to a CrN system coat to form the oxide of lubricative excellent V in a cutting mesothelium film front face, and to raise the lubricity of a CrN system by leaps and bounds. On the other hand, although a CrN system coat has lubricity, its degree of hardness is not not much desirable from a low wear-resistant viewpoint. In order to conquer this fault, addition of Si or Ti is effective. It is possible to be able to give abrasion resistance and to make a cutting life improve further, the degree of hardness of a CrN system coat improving by Si and Ti addition, and maintaining result lubricity. Furthermore, it is more desirable to carry out compound addition of V of a lubricative improvement, Ti of the improvement in a degree of hardness, and a kind of Si.

[0009] Next, the reason for having carried out numerical limitation is explained. The toughness of cemented carbide fell that it was less than 5 % of the weight, and since adhesion with steel would become remarkable if it becomes easy to generate a chipping and exceeds 13 % of the weight, Co content was made into 13 or less % of the weight 5% of the weight or more. Solid solution strengthening of Co was not enough in it being less than 3.565A, and during cutting, generating of the adhesion accompanying generating of plastic deformation and it arose, and since it was not desirable, the lattice constant of Co was made into 3.565A or more. Since it became it easy to generate adhesion to be less than 15kA/m, coercive force was made into 15 or more kA/m. the still more desirable range -- 5 - 8% of the weight of Co content -- superhard -- receiving -- 15 or more kA/m and 8 - 11% of the weight of Co content -- superhard -- receiving -- 20 or more kA/m and 11 - 13% of the weight of Co content -- it receives superhard and is 25kA/m or more.

[0010]

[Example] According to an example, this invention is explained below. By the arc ion plating method, the example of this invention and the example of a comparison which are shown in Table 1 were created. The presentation of a coat was adjusted by adjusting the presentation of the metal target of the cathode which is an evaporation source. one side of a furnace -- a TiAl system target and the opposite side -- Cr system target -- installing -- alternation -- discharge \*\*\*\*\* -- it multilayered by things. The bias voltage which carries out the seal of approval of the covering conditions to a base set 150V and reaction pressure constant at 1Pa, and the thickness of film was made into the total thickness of 3000nm in all examples. After cemented carbide mixed among alcohol WC powder which doped with a commercial mean particle diameter [ 0.5micro, 0.8micro, and 1.5micro ] Cr, and Co powder of this 1mu by attritor for 10 hours, it was made to dry, and it carried out the rubber press of the round bar, and created it by carrying out vacuum sintering for 1350 degrees C - 1400 degree-C 1 hour. WC particle size and sintering temperature adjusted the coercive force of an alloy. Moreover, in the alloy of the example of this invention, by enclosing the nitrogen gas after sintering, sudden cooling was performed and the lattice constant of Co made into the purpose was obtained. Furnace cooling was carried out in the example of a comparison.

[0011]

[Table 1]

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No.	母材組成(wt%)			WC粒徑 μm	超硬合金特性		被膜		層數	
	WC	Co	Cr		保磁力 kA/m	格子定 數(A)	TiAlN系	CrN系		
本發明例	1	bal	5.5	0.5	0.8	35.5	3.570	50A150Ti-N	95Cr5V-N	6
	2	"	5.5	"	1.5	25.9	3.569	"	"	6
	3	"	8.0	"	0.6	34.0	3.570	"	"	6
	4	"	8.0	"	0.8	30.5	3.566	"	"	6
	5	"	8.0	"	0.8	32.2	3.574	"	"	6
	6	"	8.0	"	1.5	19.8	3.568	"	"	6
	7	"	12.5	"	0.6	28.5	3.569	"	"	6
	8	"	12.5	"	0.8	22.1	3.569	"	"	6
	9	"	12.5	"	0.8	24.0	3.574	"	"	6
	10	"	8.0	"	0.8	30.5	3.568	50A150Ti-95N50	95Cr5V-N	6
	11	"	"	"	"	"	"	50A150Ti-90N100	"	6
	12	"	"	"	"	"	"	50A150Ti-95N5B	"	6
	13	"	"	"	"	"	"	50A150Ti-90N10B	"	6
	14	"	"	"	"	"	"	50A150Ti-95N5C	"	6
	15	"	"	"	"	"	"	50A150Ti-N	95Cr5V-95N50	6
	16	"	"	"	"	"	"	"	95Cr5V-95N5B	6
	17	"	"	"	"	"	"	"	95Cr5V-95N5C	6
	18	"	"	"	"	"	"	"	95Cr5Si-N	6
	19	"	"	"	"	"	"	"	95Cr5Ti-N	6
	20	"	"	"	"	"	"	"	90Cr5V5Si-N	6
	21	"	"	"	"	"	"	50A145Ti5Zr-N	CrN	6
	22	"	"	"	"	"	"	50A145Ti5Cr-N	"	6
	23	"	"	"	"	"	"	50A145Ti5Si-N	"	6
	24	"	"	"	"	"	"	50A145Ti5Nb-N	"	6
	25	"	"	"	"	"	"	50A145Ti5W-N	"	6
	26	"	"	"	"	"	"	50A145Ti5Y-N	"	6
	27	"	"	"	"	"	"	50A140Ti5Nb5Y-N	"	6
	28	"	"	"	"	"	"	65A135Ti-N	95Cr5Si-N	2
	29	"	"	"	"	"	"	"	"	20
	30	"	"	"	"	"	"	"	"	100
	31	"	"	"	"	"	"	"	"	600
比較例	32	Bal	4.5	0.5	0.8	37.5	3.565	50A150Ti-N	95Cr5V-N	6
	33	"	14.0	0.5	0.8	19.6	3.569	"	"	6
	34	"	14.0	0.5	1.5	13.5	3.569	"	"	6
	35	"	8.0	0.5	0.8	28.7	3.559	"	"	6
	36	"	"	"	"	25.6	3.556	"	"	6
	37	"	"	"	"	20.5	3.555	"	"	6
	38	"	"	"	"	"	"	TiN	50A150Ti-N	6
	39	"	"	"	"	"	"	Ti-50N50C	50A150Ti-N	6
	40	"	"	"	"	"	"	50A150Ti-N	-	1
	41	"	"	"	"	"	"	50A145Ti5Cr-N	-	1
	42	"	"	"	"	"	"	50A150Ti-95N50	-	1
	43	"	"	"	"	"	"	50A150Ti-N	50Ti50Zr-N	6
	44	"	"	"	"	"	"	50A150Ti-N	200nm MoS <sub>2</sub>	2
	45	"	"	"	"	"	"	50A150Ti-N	200nm DLC	2
	46	"	"	"	"	"	"	50A150Ti-N	50Ti50Si-N	2

[0012] In the example of this invention and the example of a comparison which were shown in Table 1, cutting evaluation was carried out by the following cutting conditions. The result is shown in Table 2. It cut until the end mill carried out the erythrochromia and broke in these conditions, and the length of cut to breakage was made into the life. Moreover, field granularity was measured and compared after 1m of cutting.

\*\* [-ed / cutting-conditions 1 ] material: SKD11 (HRC62)

Tool: phi8mm, 6 sheet cutting-edge end mill cutting speed:200 m/min cut:8mmx0.4mm delivery:0.03mm / cutting-edge dry type cutting [0013]

[Table 2]

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		切削条件1		切削条件2	
		寿命	仕上面	摩耗 $\mu\text{m}$	仕上面
本 発 明 例	1	35	0.8	145	2.2
	2	26	0.6	165	2.1
	3	34	0.7	154	2.5
	4	33	0.7	150	2.2
	5	43	0.7	132	2.1
	6	30	0.8	164	2.0
	7	25	1.2	155	2.1
	8	23	1.3	162	2.4
	9	28	0.9	142	1.8
	10	38	0.6	123	2.1
	11	42	0.5	126	2.0
	12	44	0.5	128	2.4
	13	40	0.6	119	2.0
	14	36	0.7	143	2.1
	15	44	0.5	148	1.8
	16	47	0.5	152	1.7
	17	45	0.6	147	1.9
	18	53	0.5	116	1.5
	19	45	0.7	163	2.0
	20	55	0.6	110	1.5
	21	37	1.4	135	2.4
	22	38	1.2	133	2.2
	23	36	1.1	132	2.1
	24	42	0.9	140	1.9
	25	36	0.9	139	1.8
	26	36	1.0	144	2.0
	27	39	0.8	141	2.1
	28	49	0.8	159	2.5
	29	55	0.7	141	2.1
	30	56	0.6	132	1.9
	31	60	0.6	128	1.8
比 較 例	32	3	3.5	632	11.2
	33	21	0.8	342	3.5
	34	5	0.7	380	3.2
	35	22	0.7	285	3.3
	36	17	0.7	299	3.3
	37	15	0.7	342	3.9
	38	18	2.8	238	6.2
	39	20	3.0	220	6.1
	40	25	3.1	228	5.9
	41	24	3.2	278	5.3
	42	22	2.9	321	6.2
	43	20	2.8	378	6.6
	44	20	0.6	225	6.2
	45	18	2.2	221	6.3
	46	17	2.3	245	6.9

[0014] By the examples 1-9 of this invention, it is in the inclination for a life to be prolonged, in the example which adjusted WC particle size and the amount of Co(es), and was made into the lattice constant of \*\*, so that WC particle size is small, so that clearly from Table 2. Furthermore, in the examples 10-14 of this invention, the life extension around 20% was able to be measured using the TiAlNo-CrVN film which contains oxygen for membrane quality using the cemented carbide of a sample number 4. Next, the further effectiveness was checked in the examples 15-20 of this invention which added oxygen and/or other elements to CrVN. Moreover, similarly, when other elements were added in the TiAlN film of the examples 21-27 of this invention, the operation characterized with the added element. Finally, whenever the examples 28-31 of this invention are the cases where a layer is piled up from two-layer to 600 layers, all thickness is the same and it piled up the layer, abrasion resistance has improved. Moreover, the field granularity of the example of this invention was 1.4 microns or less, and there is also no irregular cutter mark and the good result was obtained. In the example of this invention, generating of adhesion and plastic deformation is long lasting few. Under the high degree-of-hardness material high-speed conditions which especially plastic deformation tends to generate, it is clear that a difference with the example of a comparison is also still more remarkable.

[0015] In the example 32 of a comparison with few amounts of Co(es) in the example of a comparison, and the

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examples 33 and 34 of a comparison with many amounts of Co(es), it became a life by the initial deficit and wear. In the examples 35-37 of a comparison which made the lattice constant less than 3.565, although it was good, when the base material was exposed, wear advanced quickly, and it became a life the early stages of cutting. Furthermore, in the examples 38-46 of a comparison which examined the configuration of various membraneous qualities and the film using the base material of the example 37 of a comparison, although some effectiveness was good, when the base material was exposed, wear advanced quickly, and it became a life the early stages of cutting when the film of a certain thing acts. [0016] Furthermore, in the example of this invention and the example of a comparison which were shown in Table 1, the ball end mill was manufactured, and the maximum wear of the peripheral cutting edge after 50m cutting was measured and compared in the following conditions. Moreover, machined surface granularity was measured and compared in the cutting direction after 50m cutting. The result is also written together to Table 2.

\*\* [-ed / cutting-conditions 2 ] material: S50C (HRC35)

Tool: phi10mm, ball-end-mill cutting speed:314 m/min cut:0.3mm, pick 0.3mm delivery:0.5mm / cutting-edge dry type cutting [0017] From Table 2, if the examples of this invention are conditions which continue and perform only cutting near [ peculiar to a ball end mill ] the center of rotation and the damage on near the center of rotation, especially the effect of adhesion are observed, also after 50m cutting, wear is as small as 165 microns or less, and there is little adhesion etc., 2.4 microns or less are stabilized by field granularity, and it is obtained. In the example of a comparison, although abrasion loss is also large, field granularity serves as a big numeric value more than it. This is because it is in the condition that some swarfs cause adhesion to a base material, and a cutting side can be plucked after 50m cutting which a base material exposes. Moreover, very long cutting was attained by control of the plastic deformation generated in the edge of a blade in the high speed cutting of high degree-of-hardness material at prevention of the adhesion of \*\* -ed material, and a list by this invention. Moreover, same result was brought also in cutting of carbon steel. It is needless to say that this is based on the synergistic effect of the limited cemented carbide and the limited coat. Moreover, the same effectiveness was checked also in the \*\* -ed material of others to which adhesion tends to generate the example of this invention.

[0018]

[Effect of the Invention] By applying this invention, the long tool life was acquired by dry type high speed cutting. While excelling in the high degree-of-hardness material which makes adhesion and plastic deformation-proof nature indispensable especially, also in the \*\* -ed material of others which adhesion tends to generate, it is the same.

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